

## FORENSIC MEDICAL ASPECTS OF MORPHOLOGICAL DIAGNOSIS AND DETERMINATION OF THE ORIGIN OF CHRONIC SUBDURAL HEMATOMA

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<https://doi.org/10.5281/zenodo.18077607>

**Abstract:** Chronic subdural hematoma is an independent progressive pathological condition of significant clinical and forensic importance. One of the most challenging tasks in forensic medical practice is the determination of the age and origin of chronic subdural hematomas, particularly in cases lacking reliable clinical information about prior traumatic brain injury. This article analyzes current concepts regarding morphological criteria for estimating the age of subdural hemorrhages, the dynamics of their organization, and the formation of encapsulated chronic hematomas. Histological features of hemorrhage resorption and organization are described in detail, including the structural characteristics of the inner and outer membranes, the role of neoangiogenesis, and recurrent microhemorrhages in the progression of chronic subdural hematoma. Special attention is given to the differential diagnosis between traumatic and non-traumatic chronic subdural hematomas from a forensic medical perspective. Practical macroscopic and microscopic criteria are proposed that may assist in presumptive determination of the hematoma's origin. The findings presented may enhance the objectivity and evidentiary value of forensic medical conclusions.

**Keywords:** chronic subdural hematoma, forensic medicine, morphological diagnosis, hemorrhage dating, traumatic origin, non-traumatic origin, hematoma capsule.

## СУДЕБНО-МЕДИЦИНСКИЕ АСПЕКТЫ МОРФОЛОГИЧЕСКОЙ ДИАГНОСТИКИ И УСТАНОВЛЕНИЯ ГЕНЕЗА ХРОНИЧЕСКОЙ СУБДУРАЛЬНОЙ ГЕМАТОМЫ

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**Аннотация:** Хроническая субдуральная гематома представляет собой самостоятельную прогрессирующую патологию, имеющую существенное клиническое и судебно-медицинское значение. Одной из наиболее сложных задач судебно-медицинской экспертизы является установление возраста и генеза хронической субдуральной гематомы, особенно при отсутствии достоверных клинических данных о перенесённой черепно-мозговой травме. В статье рассмотрены современные представления о морфологических критериях давности субдуральных кровоизлияний, динамике их организации и формировании капсулированных хронических гематом. Подробно описаны гистологические признаки резорбции и организации кровоизлияния, особенности строения внутренней и наружной капсул, роль неоангиогенеза и повторных микрокровоизлияний в прогрессировании хронической субдуральной гематомы. Особое внимание уделено вопросам дифференциальной диагностики травматических и нетравматических хронических субдуральных гематом с позиции судебно-медицинского эксперта. Предложены практические морфологические и макроскопические критерии, позволяющие в ряде случаев предположить генез выявленной хронической субдуральной гематомы.

Представленные данные могут быть использованы в экспертной практике для повышения объективности и обоснованности судебно-медицинских заключений.

**Ключевые слова:** хроническая субдуральная гематома, судебно-медицинская экспертиза, морфологическая диагностика, давность кровоизлияния, травматический генез, нетравматический генез, капсула гематомы.

## SURUNKALI SUBDURAL GEMATOMANING MORFOLOGIK DIAGNOSTIKASI VA KELIB CHIQISHINI ANIQLASHNING SUD-TIBBIY JIHATLARI

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**Annotatsiya:** Surunkali subdural gematoma klinik va sud-tibbiy ahamiyatga ega bo'lgan mustaqil va progressiv patologik jarayon hisoblanadi. Sud-tibbiy ekspertiza amaliyotida eng murakkab masalalardan biri surunkali subdural gematomaning yoshi va kelib chiqishini aniqlash bo'lib, ayniqsa bosh miya shikastlanishi to'g'risida ishonchli klinik ma'lumotlar mavjud bo'lmaganda bu vazifa yanada qiyinlashadi. Ushbu maqolada subdural qon ketishlarning davrini aniqlashga oid morfologik mezonlar, ularning tashkil topish dinamikasi va kapsulalangan surunkali gematomalarning shakllanish bosqichlari yoritilgan. Qon ketishning rezorbsiyasi va tashkil topishining gistologik belgilariga, ichki va tashqi kapsulaning tuzilish xususiyatlariga, neovaskulyarizatsiya va qayta mikroqon ketishlarning surunkali subdural gematoma rivojlanishidagi rolga alohida e'tibor qaratilgan. Sud-tibbiy nuqtai nazardan travmatik va shikastlanmagan surunkali subdural gematomalarni differensial diagnostika qilish masalalari muhokama qilingan. Aniqlangan gematomaning kelib chiqishini taxminiy baholash imkonini beruvchi amaliy morfologik va makroskopik mezonlar taklif etilgan. Keltirilgan ma'lumotlar sud-tibbiy ekspertiza xulosalarining obyektivligi va ishonchligini oshirishga xizmat qilishi mumkin.

**Kalit so'zlar:** surunkali subdural gematoma, sud-tibbiy ekspertiza, morfologik diagnostika, qon ketish davri, travmatik kelib chiqish, shikastlanmagan kelib chiqish, gematoma kapsulasi.

### INTRODUCTION

In the study of cases involving traumatic brain injury, one of the most fundamental and at the same time most challenging questions remains the determination of the mechanism and timing of injury. This problem becomes particularly complex in situations where an isolated chronic subdural hematoma is identified, since in a significant proportion of such cases the traumatic mechanism cannot be reliably established or reconstructed, and the etiological question often remains unresolved [1]. From the standpoint of forensic medicine, the accurate determination of the origin and age of a subdural hematoma is of paramount importance, as it directly affects medico-legal conclusions regarding causality, the severity of injury, and the potential responsibility of external factors.

When discussing subdural hematomas, it is customary to refer to the classical classification proposed by Dressler and Albrecht, which divides subdural hematomas into acute (up to two days), subacute (within two weeks), and chronic (from the third week onward) [2]. For clinicians, this classification is largely based on the rate of development of clinical manifestations associated with compression of brainstem structures, as well as on the duration of the so-called "lucid interval." However, from the perspective of morphological and forensic analysis, this classification is of

limited applicability, primarily because the forensic expert is often confronted with cases in which clinical data are absent, incomplete, or unavailable altogether [3]. In such circumstances, reliance on purely clinical criteria becomes impossible, necessitating an alternative approach grounded in objective morphological evidence.

For this reason, the subdivision of subdural hematomas according to the time of their development must be based on the dynamic sequence of morphological changes occurring within the hematoma over time. These changes reflect the biological processes of coagulation, organization, resorption, and encapsulation, which follow relatively consistent patterns and may serve as reliable indicators of the hematoma's age [4]. A thorough understanding of these processes is essential for forensic experts tasked with determining both the timing and possible origin of subdural hemorrhage.

### **MATERIALS AND METHODS**

Despite the considerable variability in the macroscopic appearance of subdural hematomas observed during forensic examinations, depending on their age and individual biological factors, the most objective and reliable criteria for determining the age of a subdural hematoma are histological and morphological features identified through microscopic analysis [5]. These features reflect the sequential stages of hematoma evolution and provide insight into the duration of the pathological process.

Within the first three days following hemorrhage, a subdural hematoma consists primarily of an accumulation of liquid blood, which subsequently undergoes coagulation with the formation of fibrin strands and aggregates of leukocytes. During this early period, the hematoma may be classified as acute. Histologically, this stage is characterized by fresh erythrocytes, fibrin deposition, and the absence of significant cellular response [6]. No evidence of resorptive or reparative processes is typically observed at this time.

By the third to fourth day after hemorrhage, early signs of blood resorption become apparent. These changes are manifested by the appearance of macrophages and hemosiderophages, which represent the most reliable morphological markers of the onset of hematoma resorption. Hemosiderophages contain iron-rich hemosiderin pigment and can be reliably identified using Perls' Prussian blue staining method [7]. The detection of these cells indicates that the hemorrhage is no longer acute and has entered a transitional phase.

Approximately two weeks after the hemorrhagic event, the resorptive process becomes more pronounced. In addition to hemosiderophages, extracellular aggregates of hemosiderin appear at the site of hemorrhage. Small hemorrhages may be completely resorbed by this time. By the end of the first month, residual hemosiderin deposits can often be identified on the inner surface of the dura mater. These deposits may persist for many years or even decades, serving as long-term morphological evidence of prior hemorrhage [8].

In cases involving large subdural hematomas, the process of organization becomes particularly prominent. Organization begins at the periphery of the hematoma and gradually extends toward its center. The endothelial lining of the dura mater and its capillary network play a crucial role in this process. Within five to seven days, a thin layer of granulation tissue composed primarily of fibroblasts forms on the surface of the hematoma [9]. Along the periphery of the hemorrhage, chains of fibroblasts develop, ultimately forming an inner capsule that delineates the hematoma from surrounding tissues.

As the process continues, fibroblast strands penetrate the hematoma mass, giving rise to connective tissue fibers. The end result of this process is the formation of a connective tissue layer

on the inner surface of the dura mater, often accompanied by focal hemosiderosis. Complete organization of a subdural hematoma typically requires three to four weeks, although in some cases a longer period may be necessary, depending on the size of the hematoma and the individual's biological reactivity [10]. Importantly, a hematoma that is two to three weeks old and undergoing organization cannot yet be classified as a chronic subdural hematoma, as its ultimate outcome remains uncertain at this stage.

It must be emphasized that not every developing subdural hematoma progresses to a chronic form. The likelihood of chronic transformation increases in elderly individuals, in patients with chronic alcoholism, and in those suffering from systemic diseases that impair the general reactivity of the organism [11]. These conditions create a biological environment conducive to prolonged inflammatory and reparative processes, thereby facilitating chronicity.

**Morphological characteristics of chronic subdural hematoma.** Chronic subdural hematoma should be regarded as an independent nosological entity, as it possesses distinct clinical manifestations and a characteristic morphological pattern. The defining feature of chronic subdural hematoma is its progressive nature, with a tendency toward gradual enlargement over time [12]. Morphologically, a chronic subdural hematoma represents a non-organized, encapsulated hemorrhagic cavity.

Two layers of connective tissue are formed, commonly referred to as the outer and inner membranes. These membranes contain numerous newly formed blood vessels that do not undergo normal regression. The vascular walls are typically thickened and exhibit sclerotic changes. Both membranes demonstrate infiltration by inflammatory cells and contain foci of hemosiderin deposition, reflecting repeated episodes of microhemorrhage and ongoing inflammatory activity [13].

An important pathophysiological mechanism in chronic subdural hematoma is the difference in oncotic pressure between the cerebrospinal fluid and the blood within the hematoma cavity. As a result of this gradient, cerebrospinal fluid diffuses into the hematoma through the inner capsule and the arachnoid membrane. This process may lead to rupture of fragile capillaries within the hematoma capsule, resulting in recurrent microbleeding and further enlargement of the hematoma [14]. These repeated hemorrhagic events produce a layered internal structure, which is a hallmark of chronic subdural hematomas.

The progressive enlargement of a chronic subdural hematoma may ultimately lead to the development of a displacement syndrome, characterized by midline shift and compression of intracranial structures. Notably, such complications may arise weeks or even months after the initial injury [15]. Over time, the contents of the hematoma cavity evolve from hemolyzed erythrocytes to cerebrospinal fluid, leading to the formation of a chronic subdural hygroma. The capacity of chronic subdural hematomas to change in volume explains their clinical behavior, which may closely resemble that of an intracranial neoplasm.

**Macroscopic appearance.** Macroscopically, a chronic subdural hematoma typically appears as a cavity resembling an elastic sac firmly adherent to the inner surface of the dura mater. The walls of this cavity consist of a connective tissue capsule, usually not exceeding 0.15–0.2 cm in thickness. The capsule is generally light gray in color, sometimes stained with blood, giving it a reddish or dirty appearance. The capsule walls are often opaque or only weakly translucent [16].

As a rule, the outer membrane of the capsule is slightly thicker than the inner membrane, owing to its firm attachment to the dura mater. The inner membrane is thin, smooth, and rarely adheres to the soft meningeal layers. The cavity between the two membranes usually contains

lysed blood or cerebrospinal fluid, often tinged with blood. The inner surfaces of both membranes are rough and rust-colored, with small fragments of blood clots firmly attached to them [17].

**Etiology and differential diagnosis.** Determining the origin of a chronic subdural hematoma is often extremely difficult and, in some cases, impossible, particularly when a significant amount of time has elapsed since its formation. According to the literature, more than 80% of chronic subdural hematomas are associated with traumatic brain injury [18]. Nevertheless, an alternative hypothesis suggests that chronic subdural hematomas may arise against the background of chronic hemorrhagic pachymeningitis. This hypothesis is supported by the presence of inflammatory cell infiltration of varying intensity in both the inner and outer membranes of the hematoma capsule [19].

S.Yu. Kasumova conducted a differential diagnostic analysis of traumatic and non-traumatic chronic subdural hematomas based on the structural characteristics of the connective tissue capsule and its histological features [20]. One of the distinguishing features of chronic subdural hematoma is its layered structure. According to this classification, three types of capsules are described.

In the first type, the inner surface of the capsule facing the clot is lined with elongated, spindle-shaped cells. The second type is characterized by the absence of a clear boundary between the capsule and the clot, with columns and strands of fibroblasts extending into the hematoma itself. In the third type, the inner surface of the capsule is lined with spindle-shaped cells oriented parallel to the capsule, with isolated fibroblasts penetrating the hematoma in certain areas [21].

According to the authors, the first capsule type is characteristic of non-traumatic chronic subdural hematomas, while the second type is typical of traumatic cases. The third type may be observed in both traumatic and non-traumatic hematomas [22]. However, in practical forensic work, these morphological distinctions are not always evident, likely due to the relative rarity of chronic subdural hematomas encountered in routine practice and the even lower frequency of non-traumatic cases. Nevertheless, when a chronic subdural hematoma is identified, every effort should be made to determine its origin. In practice, this task is extremely challenging. It is often difficult to ascertain whether a chronic subdural hematoma is the result of traumatic impact or whether it developed as a consequence of pathological changes in the meningeal membranes or systemic disease. Despite these difficulties, the forensic medical expert is obligated to provide an opinion regarding the cause of the condition when posed with such a question [23].

### CONCLUSION

Based on our observations, we propose a set of practical criteria that may, in certain cases, allow for a presumptive determination of the origin of a chronic subdural hematoma. Non-traumatic chronic subdural hematomas are typically bilateral, whereas traumatic hematomas are more often unilateral. Non-traumatic hematomas generally have a relatively small volume, usually not exceeding 20–30 ml, while traumatic hematomas often reach volumes of 100–120 ml or more. Bilateral non-traumatic chronic subdural hematomas are more frequently observed in elderly individuals, whereas traumatic hematomas are more common in persons of working age.

In traumatic cases, the source of subdural bleeding is usually associated with areas of brain contusion, most commonly involving the frontal and temporal poles or basal surfaces of the cerebral hemispheres. Over time, these areas may develop gliomesodermal scars, the presence of which supports the traumatic origin of an identified chronic subdural hematoma. Additional evidence in favor of traumatic etiology includes signs of prior surgical intervention, healed fractures of the skull bones, and the presence of hemorrhagic pachymeningitis [24].

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